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POTASH PRODUCTION IN CALIFORNIA AND POTASH FROM KELP

BY

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POTASH PRODUCTION IN CALIFORNIA.

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With the cessation in the customary import of potash salts from Germany and the danger of this interruption being prolonged indefinitely, there is renewed interest in the possibility of securing a supply of the much-needed compounds from domestic sources, and especially from our Pacific States.

Attempts to develop a domestic potash industry are more advanced in California than in any other section. No less than six companies are actively engaged in this field. (A list of these firms may be obtained from the Bureau of Foreign and Domestic Commerce.)

MINERAL SOURCES.

Two companies are seeking to extract potash from mineral deposits within the State. These deposits contain frequently relatively high percentages of potash, but not sufficiently high to warrant transportation without previous concentration. This factor of transportation presents the most serious difficulty in the whole problem, as the chief demand for potash as a fertilizer comes from the eastern half of the country, and very largely from the Gulf States. The California State Board of Mines expresses strong doubts as to a possible profitable exploitation of the deposits in the southeastern section of the State on account of their remoteness from existing conveniences for transportation.

The most promising source of potash is in the saline deposits at Searles Lake in San Bernardino County, where the American Trona Co. has erected a development plant and is actively investigating the methods proposed for effecting a complete commercial utilization of the vast supply of raw material in sight. The deposits are not only rich in potash but contain, also, borax, common salt, sodium sulphate, and sodium carbonate. The manager of the company is hopeful of putting potash salts on the market within a few months.

Deposits in the Imperial Valley, to the east of San Diego, are reported as offering some hope of satisfactory commercial development, when projected rail connection is established in 1916.

One California company, which has expended \$150,000 in studying the possibilities of finding potash in workable quantities in Nevada, has abandoned the quest and reports that there is no promise of ever securing a supply from that State.

POTASH FROM ALUNITE.

It is worthy of note in this connection that active experiments have been conducted by large chemical works in Ohio for the industrial extraction of the potash present in the alunite of Marysville, Utah. These experiments, performed on carload lots, show that the method

used is technically satisfactory. The high cost of railroad transportation from Utah to the Atlantic seaboard is at present a serious obstacle in marketing the sulphate of potash obtained in Utah, in direct competition with potash salts of German origin, on the basis of the rates hitherto current. The erection of the requisite plant at Marysville for extracting the sulphate has been begun, and it is probable that a suitable market will eventually be found for the product in the Central States. There is a large consumption of potash salts on the sugar plantations of Hawaii, and this market would also be open to the Utah products. It is stated that powerful fertilizer interests in Chicago are backing financially the effort to exploit the alunite deposits of Utah.

POTASH SALTS FROM KELP.

The utilization of the enormous masses of seaweed growing off the Pacific coast seems to offer better chances of solving the potash problem. Considerable doubt is expressed by engineers, who have carefully studied the methods thus far employed to develop the kelp industry, as to the possibility of its becoming a serious factor in the production of potash salts.

The leading company engaged in the extraction from kelp is, however, quite confident of its ability to build up the industry on a substantial commercial basis. It is now manufacturing regularly a crude potassium chloride ranging in strength from 85 to 95 per cent of pure KCl. This is all sold for use as a fertilizer. The present output is 1 ton per day. Prospective enlargement of the plant will double this output.

HARVESTING KELP.

The raw material, the giant kelp of the Pacific coast, is gathered systematically in various ways. One method is to cut the kelp 6 to 8 feet below the surface of the sea by means of rotating knives. The loosened kelp is allowed to float ashore or brought ashore in barges. By another method the cutting is effected by the aid of reciprocating knives 16 to 18 inches below the surface, and the kelp is conveyed by endless chains upon barges. In a third method the cutting takes place at a depth of 8 to 10 feet. Horizontal knives are used in connection with an underswinging endless chain.

The most satisfactory device is based upon the principle of the ordinary hay mower. A horizontal scythe blade, of about 10 feet in length, is flanked at both extremities by vertical blades, about 4 feet long. The three cutting systems, having a stroke of about 4 inches, are operated by a gasoline engine on a flat-decked barge. The framework supporting the cutting machinery is lowered into the water to a depth of about 4 feet. It carries an endless belt consisting of coarse fish net stretched over chains. This conveys the kelp as fast as it is cut on board the barge. A motor launch propels the latter through the kelp beds at the rate of 4 miles per hour.

On the barge the kelp is discharged from the endless belt into a hopper and passes through a set of revolving knives, which cut it into small pieces about 6 inches in length. From this chopper the

kelp is discharged into an open barge, which is towed ashore and unloaded at the factory. Such a device harvests over 25 tons of kelp per hour and seems to have satisfactorily solved the problem of the economic gathering of the raw material. The entire cost per ton of wet kelp landed at factories is now less than 20 cents.

DIRECT USE OF KELP.

Wet kelp contains on an average 4 per cent of potassium chloride. It can advantageously be used as a fertilizer, and is so used to an increasing extent along the Pacific littoral.

Air-dried kelp contains about 15 per cent of potash (K_2O), 2 per cent of nitrogen, and 1.5 per cent of phosphoric acid. It is readily pulverized and is of equal value as a fertilizer with equivalent amounts of potash in the customary form of chloride and sulphate. Taking all factors into consideration—cost of production, cost of handling, and physical properties—dried powdered kelp seems to be the form in which a substantial commercial demand can be most quickly secured. It will rapidly appeal to the manufacturer of mixed fertilizers.

PREPARATION OF POTASH SALTS FROM KELP.

There is as yet no standard method for extracting the potassium chloride of kelp on an industrially profitable scale. The American Potash Co., which has a plant of some size at Long Beach, uses a "secret process," by which it expects to place upon the market iodine and various other by-products, as well as technically pure potassium chloride.

In kelp potassium chloride and sodium chloride are present usually in the proportions of 3 to 2. They constitute the bulk of the mineral constituents, but are accompanied by small amounts of calcium and magnesium salts and of iodides. The separation of the two chlorides from the organic residue constitutes the chief difficulty to be overcome.

Filtration methods applied to green kelp have not been successful, as the absence of fiber permits much of the organic matter to pass through the filter medium, causing the latter to be quickly clogged. Diffusion methods, similar to those used so satisfactorily in sugar manufacture, have been tried. Thus far they give no promise of industrial application.

More success is indicated by experiments now in progress to coagulate the organic tissues of kelp, and thus permit easy filtration.

It is worthy of note in this connection that a process recently patented in Great Britain offers a new method of overcoming the difficulty mentioned above. According to the British Patent No. 1,766 of 1915, issued to Beborg, Testrup and Techno-Chemical Laboratory, kelp is reduced to pulp, and then forced by pressure through a heater at a temperature sufficiently high to destroy the slimy, water-binding constituents. The pulp is then cooled and pressed. In the effluent water are found nearly all of the potassium and sodium salts originally present in the kelp, as well as the iodides.

Once removed from the plant, the separation of potassium chloride from sodium chloride is comparatively easy. It is based upon the

fact that the potassium salt is much more soluble in boiling water than is the sodium salt, while the reverse is the case at ordinary temperatures. Alternate crystallizations of saturated solutions, first in a hot vat and then in a cool vat, would result in the accumulation of potassium chloride in the latter and of sodium chloride in the former. Concentrated mother liquors could be treated for the recovery of iodine.

Assuming a satisfactory solution of the coagulation problem, this combined industry would produce pure potassium chloride, pure sodium chloride (table salt), potassium iodide, and a cattle food from the residual kelp, containing 4.5 per cent nitrogen.

EXTENT OF THE KELP SUPPLY.

The area of the kelp beds along our Pacific coast, including Alaska, is nearly 400 square miles. It is estimated by Government experts that the annual cuttings, including two cuttings per annum off the coast of southwestern California, would yield 59,000,000 tons of kelp. This is equivalent to 2,300,000 tons of potassium chloride.

The value of this quantity of potassium chloride, if marketed at ante bellum rates, would be about \$90,000,000. If, however, the kelp crop were dried and sold at normal prices for both potash and nitrogen content, its value would exceed \$150,000,000.

The imports into the United States of potash salts for the fiscal year ending June 30, 1914, were:

	Tons.	Value.
Muriate of potash (potassium chloride).....	237,890	\$7,915,000
Carbonate of potash.....	92,000	615,000
Sulphate of potash.....	45,140	1,898,000
Nitrate of potash (crude saltpeter).....	1,580	115,000
Kainit.....	526,000	2,580,000
Manure salts.....	261,000	2,757,000
Other potash compounds.....		978,000
Total.....		16,858,000

It is evident that any extended successful development of the industrial extraction of potash salts from the vast kelp beds would ultimately place this country in a position to cover not only the large domestic demand for these compounds, but to meet German competition in other lands, more especially in supplying the wants of countries on the Pacific.

GROWING SCARCITY OF POTASH SALTS.

The "potash famine" is already being felt almost as keenly as the "dyestuff famine." Since February 1 but one cargo of German potash has been received in an American port. In the meantime the demands of fertilizer works for their customary supplies have become increasingly insistent.

Potash salts, which sold currently a year ago at \$38 per ton, are quoted September, 1915, at \$300. Over 20,000 tons of potash salts, the property of American firms, purchased before the recent embargo on German exports, are now interned on three steamers in German ports. The release of these cargoes is the subject of negotiations between the American and German Governments.

POTASH FROM KELP.

[Commerce Reports, June 19, 1915.]

The Bureau of Soils in the Department of Agriculture has issued a most timely and important monograph on the kelp beds in the Pacific found off a large proportion of our littoral, including Alaska.

The report in question bears the title "Potash from Kelp," and is prepared by Dr. Frank K. Cameron, who has the supervision of chemical, physical, and fertilizer investigations. It presents in compact form the results of an enormous amount of marine exploration and analytical work in the laboratory. Nothing has been omitted which is requisite for an adequate knowledge of the extent of the beds, the local characteristics, the percentage of potash and other valuable constituents present, the facilities for exploitation, and all the other factors which may eventually come into play, in any attempt to utilize on a generous scale, the great possibilities of this magnificent national asset.

The report in question is based upon the results obtained in 1912 and 1913 by four well-equipped survey parties cruising in sailing craft or motorboats. One party investigated the entire seacoast of Washington, Oregon, and California, extending its researches along Lower California. Another was occupied with the beds in Puget Sound. A third devoted itself to the archipelago off southeastern Alaska. The fourth party studied the waters about Kodiak Island, Kenai Peninsula, and western Alaska generally.

In all cases the beds have been carefully charted and the relative values of the different stands estimated. The total tonnage of annual crops for each locality has been closely approximated, and the conditions under which harvesting can be pursued have been noted.

NATURE OF KELP.

The general results of this noteworthy survey may be summarized as follows:

Among the many varieties of algæ (seaweeds and rockweeds) growing along the Pacific coast three are of pronounced commercial importance, containing large amounts of potash and occurring in vast quantities. These are *Macrocystis pyrifera* (California kelp), *Nereocystis luetkeana* (bull kelp or bladder kelp), and *Alaria fistulosa* (stringy kelp). Some other varieties contain higher percentages of potash, but occur only in scattered groups or are not available for other technical reasons.

The three varieties differ widely in appearance and in peculiar characteristics, as evidenced by the nature of the surroundings in which they flourish best, depth of water, resistance to breakers or ocean swells, attractiveness to certain animal enemies, etc. In general they all have a holdfast, a group of tentacle-like branches not unlike the roots of land plants, by which they are anchored to rocks or some other relatively immovable substance. The stem rises from

the holdfast to the surface, terminating in the "float," a hollow organ of thick, fleshy walls, filled with air, and in consequence remaining on the surface of the sea. The fronds or leaves extend from the float. The tissues of kelp contain little or no fiber. They are easily crushed to a pulpy mass, and in this condition pass through ordinary filtering materials.

Stems of *Macrocystis* average 100 feet in length, but lengths of 1,000 feet are encountered. The leaves are usually 14 inches long. *Alaria* has very short stems, but the leaves average 40 feet in length. Both of these varieties are perennials. *Nereocystis* is an annual.

VALUE OF KELP.

The amounts of soluble salts and nitrogen compounds present in the various beds of the same kind of kelp vary very largely. Thus in different samples of *Macrocystis* potash varies from 3.1 to 27.7 per cent; nitrogen from 0.53 to 3.17 per cent. The averages of a great many analyses are as follows:

Macrocystis.—K₂O, 12.59 per cent; N, 1.57 per cent; iodine, 0.23 per cent.

Nereocystis.—K₂O, 20.1 per cent; N, 1.9 per cent; iodine, 0.13 per cent.

Alaria.—K₂O, 9.1 per cent; N, 2.6 per cent; iodine, trace.

Dried kelp contains ordinarily about 15 per cent of potash, 2 per cent of nitrogen, and 1.5 per cent of phosphoric acid (P₂O₅). It serves admirably as a manure alone, and can be used most advantageously in the manufacture of special and complete fertilizers. The harvesting of kelp, as practiced thus far, by "mowing" the beds at depths of 12 feet or less (usually 4 to 6 feet), is followed by a rapid reproduction of the plants in the case of the perennials, very much as is the rule with clover or alfalfa. Along the southern section of the coast two cuttings annually are quite practicable without affecting the permanent value of a bed. *Nereocystis* is not harvested until the spores are well ripened. Otherwise enough plants must be left in each bed to insure reseeding.

DISTRIBUTION OF KELP.

The results of the present survey show that the commercially available kelp beds of the Pacific coast and the annual harvest of kelp, with its resultant equivalent of potassium chloride, are as follows:

AREA AND TONNAGE OF PACIFIC KELP BEDS.

Region.	Area.	Fresh kelp.	Potas- sium chloride.
	<i>Sq. miles.</i>	<i>Tons.</i>	<i>Tons.</i>
Cedros Island to San Diego.....	91.4	16,979,800	649,000
San Diego to Point Conception.....	97.9	18,195,300	696,000
Point Conception to Cape Flattery.....	36.2	4,377,400	167,000
Puget Sound.....	5.0	520,000	20,000
Southeast Alaska.....	141.6	15,666,000	598,000
Western Alaska.....	17.9	3,367,000	136,000
Total.....	390.0	59,305,500	3,206,000

It is evident from the above that southeastern Alaska and the southern California coast offer the best fields, as does also the extensive stretch along the Mexican coast of Lower California to Cedros Island. The annual tonnage for this section, as well as for the adjacent section, from San Diego to Point Conception, is based upon two cuttings each season.

POTASH SALTS AVAILABLE.

The above figures show that the shallow waters of the Pacific coast, within the jurisdiction of the United States, are producing each year, without cultivation, a crop which, if simply collected and dried, possesses, as a fertilizer, at the customary antebellum prices for potash and nitrogen, a value of over \$150,000,000. If used as a source of commercial potassium chloride, the final product would have a value of \$90,000,000.

ECONOMIC IMPORTANCE.

It would appear to be thoroughly feasible to so organize the harvesting and drying of kelp along the Pacific littoral that our fertilizer industry can be promptly emancipated from dependence upon the potash salts of Germany.

The data supplied in Dr. Cameron's report are of far-reaching importance, as furnishing a trustworthy basis for the establishment upon American soil of domestic production of the salts in question, and the subject deserves full consideration in view of the urgent need at present for potash compounds by agriculture, manufacturers of explosives, glass makers, and nearly every phase of chemical industry.

IMPORTS OF POTASH SALTS FOR USE AS FERTILIZERS.

During the fiscal year 1913-14 the importations into the United States of potash salts from Germany, for use as fertilizers, amounted to 1,060,000 long tons. This total included 238,000 tons muriate of potash (containing about 80 per cent KCl), 45,000 tons of sulphate (90 per cent), 261,000 tons manure salts (averaging 20 per cent K_2O), and 526 tons kainit (averaging 12.4 per cent K_2O).

This entire amount was equivalent to 413,000 tons of pure potassium chloride. It represents approximately the current annual needs of the American fertilizer industry, as far as potash is concerned. Referring to the estimated product of our Pacific coast as tabulated above, it constitutes but one-eighth of the annual output theoretically available.

The important problem before American chemical industry is how to transform a sufficient portion of this floating mass of kelp into a dry product and transport it to our Gulf ports and Atlantic ports at a combined cost materially below what has normally been paid in the past for cargoes of German potash salts laid down at these points, where the fertilizer industry is chiefly centered.

PRICES OF GERMAN POTASH SALTS.

The prices for the German salts delivered at Gulf and Atlantic ports before the outbreak of the present war were as follows:

	K ₂ O (equivalent per cent).	Price (short tons).
Muriate of potash, 80 per cent KCl.....	50	\$38. 05
Sulphate of potash, 90 per cent K ₂ SO ₄	48	46. 30
Manure salts.....	20	13. 30
Kainit.....	12. 4	8. 25

A discount of 15 per cent from these prices is granted to purchasers of large quantities in bulk c. i. f.

The ocean freight rates on these salts, in bulk, from Hamburg averaged \$2.07 per long ton.

It is probable that transportation rates by water via the Panama Canal from San Diego and vicinity would not vary much from the Hamburg maritime rate.

Assuming a freight rate from the Pacific coast to the Atlantic coast of \$2 per short ton, and deducting 15 per cent for prices in bulk, the cost of production of dried kelp, f. o. b. California ports, should be such that it can compete easily with the German salts at the following net rates per short ton:

Muriate of potash, 80 per cent.....	\$30. 50
Sulphate of potash, 90 per cent.....	37. 40
Manure salts.....	9. 60
Kainit.....	5. 30

COST OF COLLECTING.

The production of dried kelp as a commercial article involves two distinct items of cost—(1) the gathering of fresh or wet kelp, and (2) its desiccation, with the incidental charges of storage, handling, grinding, and loading on ocean vessels.

1. The operation of cutting and collecting fresh kelp has now been well systematized and organized. As conducted at present, after the experience of two or three years, it does not exceed 20 cents per ton. (A description of the operation is found on page 4.)

The amount of dried kelp obtainable from wet kelp varies according to the plant. From 100 tons of fresh *Macrocystis* the average yield is 13.2 tons, containing 2.53 tons K₂O; from *Nereocystis*, 8.6 tons, containing 1.6 tons K₂O; from *Alaria*, 13.7 tons, containing 1.33 tons K₂O.

Leaving out of question for the time being the *Alaria* found only along the Alaska coast, and considering only the other two varieties, it is found that on an average 100 tons of wet kelp yield 10.9 tons of dried kelp containing 18.9 per cent K₂O, 2 per cent N, and 1.5 per cent P₂O₅. On this basis the operation of cutting and collecting the material for 1 ton of dried kelp costs \$1.83.

COST OF DRYING KELP.

2. The cost of drying kelp has not yet been made a subject of careful study. On the Mexican coast of South California, rapid air dry-

ing is feasible. Proceeding northward along the coast, climatic conditions become less and less favorable, and artificial drying seems unavoidable. According to the locality, kelp might be more or less dried by exposure to the open air for a short time. The operation could be completed by using a rotating drum or tube, types of which are common in various branches of manufacture. The kelp entering at one end of a tube issues dry at the other end, and falls upon a conveyor. A current of heated air passes through the tube in the opposite direction and takes up the moisture. Conditions require the removal of about 8.2 pounds of water for each pound of dry kelp produced. Laboratory observation shows that kelp is more readily dried in such devices than tankage, garbage, and fish scrap, all of which are efficiently and economically desiccated in drums or tubes.

It would appear doubtful whether the additional cost of handling, drying, grinding, storage, and loading at San Diego and vicinity would much exceed \$1 per ton of dried kelp when the industry is organized upon an extensive scale.

Under ordinary circumstances 5 pounds of coal is required for the evaporation of 100 pounds of water. The removal of the 8.2 tons of water accompanying 1 ton of dried kelp would therefore involve a fuel consumption equivalent to 820 pounds of coal. Assuming a price of \$4 per ton for bituminous coal on the Pacific coast, the cost of drying 1 ton of kelp would range downward from a maximum of \$1.64.

VALUE OF NITROGEN AND PHOSPHORIC ACID PRESENT.

In considering the value of dried kelp for a fertilizer, especially in connection with transportation problems, the amounts of available nitrogen and phosphoric acid present are important factors.

On the basis of 2 per cent of nitrogen and 1.5 per cent of phosphoric acid, a short ton of dried kelp contains the equivalent of 258 pounds of Chile saltpeter, valued at current rates at \$5.93, and of 192 pounds of superphosphate (15.5 per cent), value \$0.75. The total fertilizer value of a short ton of dried kelp, entirely apart from the potash present, is therefore \$6.68.

VALUE OF POTASH PRESENT.

In point of potash content, the dried kelp approaches very closely the category of imported German potash salts, termed manure salts, with a minimum of 20 per cent K_2O . On the basis of the rate in the table given above, viz, \$9.60, the potash in a short ton of dry California kelp is worth \$9.07.

The total value based upon potash, nitrogen, and phosphoric acid is \$15.75.

COST OF PRODUCTION—MARGIN OF PROFIT.

Against this market value is to be placed the cost of production per short ton, as outlined above:

Cutting and collecting	\$1. 83
Drying	1. 64
Grinding, handling, loading, etc. (estimated)	1. 00
General expenses, interest, etc. (estimated)	1. 00
Total	5. 47

The margin here of over \$10 is such that all closely identified with the interest of the fertilizer trade should study the possibilities of promptly utilizing the vast resources of our Pacific littoral. We have been expending annually for low-grade kainit and manure salts \$5,330,000. The equivalent supply can be furnished by our own kelp beds, without having recourse to other operations than those of a purely mechanical nature.

In the case of the more concentrated muriate and sulphate of potash, which we import annually to the value of over \$9,800,000, the margin of economy would be somewhat lessened, but not materially. It must not be forgotten that dried kelp, after deduction of the normal nitrate and acid phosphate present, carries 24.4 per cent of K_2O , and is to be regarded as such, when used for making complete fertilizers. Unquestionably, with a slight change of formulas and standards, the major portion of the muriate and sulphate now imported from Germany for fertilizer purposes could be effectively replaced by the American product with pronounced economy on the basis of antebellum prices.

Needless to say, with muriate now selling at \$300 per ton instead of \$38, there is every inducement for the quick utilization of the Pacific beds.

OTHER POTASH COMPOUNDS.

We import other potash compounds to the value of \$1,700,000 annually, including the carbonate (92,000 tons) and saltpeter (1,580 tons). The technical processes for the economical separation from kelp of potassium chloride in a more or less pure form may require time for development, but we can count confidently upon an early solution of the problem and the ultimate emancipation of American industrial chemistry from dependence upon a single, distant, foreign source of potash.

SIMILARITY BETWEEN THE POTASH AND DYESTUFF SITUATIONS.

There is a striking similarity between the dyestuff situation and the potash situation in the United States. In both cases the country possesses the raw material in the greatest abundance, and the consumption of final products is enormous. Yet for both categories of compounds the United States depends upon German sources. The potash famine and the dyestuff famine, affecting so seriously the interests of American agriculture, of the great textile industries, and of scores of allied branches, should work like a leaven to stimulate capital and enterprise to bring about a prompt and permanent change in the existing dependence upon foreign effort and intelligence.

JURISDICTION OVER KELP BEDS.

The kelp beds along the Pacific coast are, with insignificant exceptions, inside the 3-mile limit at mean low water, and are subject to the jurisdiction of the several States within whose bounds they lie, or of the Federal Government in the case of Alaska. The paramount right of the Federal Government to regulate commerce and navigation naturally extends to the areas in question.

At present the collection of kelp is free to all. Statutory regulation will inevitably be necessary at an early date in order to give

capital the needed assurance of security in making large investments and to insure the permanent conservation of the great beds.

KELP CULTIVATION.

For the immediate future the potash question evidently demands nothing beyond a rapid and intelligent utilization of the immense supply of kelp as nature has provided it, due regard being paid to the conditions requisite for uninterrupted annual reproduction.

Dr. Cameron's monograph cites, however, the occurrence, in small quantities, of varieties of kelp which contain notably higher percentages of potash than is the case with the three varieties mentioned above, found in such abundance and constituting at present the only supply of industrial importance. For instance, the variety *Pelagophycus porra*, or elk kelp, has uniformly a higher content of potash than any other known kelp. It is found throughout the area of kelp beds off the coast of Lower California, but only in scattered groups and single plants along the seaward edge of the great *Macrocystis* stands.

There would appear to be here a distinct opportunity for investigation under Federal auspices as to the possibility of eventually substituting beds of *Pelagophycus* for the existing stands of other varieties. This would involve an intimate study of the life history of the varieties concerned. Apparently the best promise of success would be offered by the fields of *Nereocystis*, which seems to depend so largely on annual propagation from the spores formed on the leaves.

As the percentage of potash in *Macrocystis* is, however, so conspicuously inferior to that of *Nereocystis*, and the former predominates in the localities apparently favorable for the isolated growths of *Pelagophycus*, any study leading to the successful substitution of the last mentioned for the chief variety found in the San Diego region would be of prime importance.

Each added per cent of potash in the final product of dried kelp diminishes by so much the cost of production and the transportation charges per effective unit of alkali, and increases the value of the kelp as raw material for the manufacture of technical and pure potassium compounds.

Satisfactory proof that the productive power of the areas, now distinctly favorable to the growth of the most valuable variety of kelp, are economically susceptible of a pronounced increase, would be a powerful factor in attracting capital to this field.

This report of the Bureau of Soils supplies in a most comprehensive form all of the physical, physiological, and topographical data needed by those interested in building up a national industry. It is accompanied by 40 fine plates, illustrative of the occurrence, appearance, life history, and collection of the three important varieties, and by a portfolio of 54 large maps, showing in detail the location, density, and character of the kelp beds of the Pacific coast, including Alaska and a part of Lower California.

The report, with its portfolio of maps, can be obtained by application to the Superintendent of Documents, Government Printing Office, Washington; price \$2.

